CBCS SYLLABUS
FOR
THREE YEARS UNDER-GRADUATE COURSE
IN
PHYSICS (HONOURS)

(w.e.f. 2022-23 academic year)

PROGRAMME OUTCOME

The Undergraduate (UG) programme of Physics is constructed of UG (Hons) and UG (programme). The syllabus is based on the CBCS system which covers almost all the fields of Physics. The students will be enriched with plenty of knowledge after the completion of the course. The complete syllabus is compatible with the competitive examination for higher studies and research. The project work is included in the new syllabus which will motivate students for higher studies and research. In this programme there are various inter- and multidisciplinary courses. The students will acquire inter- and multidisciplinary skills which will be of tremendous value to them.

SEMESTER-I

Core T1 – Mathematical Physics-I (4 Credits)

1. Calculus

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Euler’s theorem of homogeneous function of degree n. Particular Integral.

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Cyclic and chain rule of partial derivative.

2. Vector Calculus

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.

Vector Integration: Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs).

3. Orthogonal Curvilinear Coordinates

Orthogonal Curvilinear Coordinates. Unit vectors in curvilinear coordinate system. Arc length and volume element. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

4. Fourier Series

Periodic function, Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity. Application to triangular, square and saw tooth wave.

5. Frobenius Method and Special Functions

Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel. Properties of Legendre

Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions ($J_0(x)$ and $J_1(x)$) and Orthogonality.

6. Some Special Integrals

Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

7. Partial Differential Equations

Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Diffusion Equation.

Reference Books

► Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.

► An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning

► Differential Equations, George F. Simmons, 2007, McGraw Hill.

► Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.

► Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book

► Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning

► Mathematical Physics, Goswami, 1st edition, Cengage Learning

► Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press

► Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.

► Essential Mathematical Methods, K.F.Riley&M.P.Hobson, 2011, Cambridge Univ. Press

► Mathematical methods in the Physical Sciences, M. L. Boas, 2005, Wiley.

Course Outcomes:

1. Students will develop the concepts of vector and basic knowledge of the vector differential operator Del and understand the operation on the scalar and vector field.

2. Learn about vector integration and related theorems like Divergence and Green theorem etc.

3. Acquire Knowledge about the orthogonal curvilinear coordinate systems and their transformation relation with special emphasis on spherical polar system.

4. Able to think about the mathematical formulation of Fourier series, half range series, Fourier transformation etc.

5. Get knowledge about ODE learn to solve series solution of 2nd order ODE, Bessel's differential equation, Legendre's differential equation, Partial differential equations, Solution of Laplace's equation in different coordinate systems by the method of separation of variables.

Core P1 – Mathematical Physics-I Lab (2 credits)

1. Introduction and Overview

Computer architecture and organization, memory and Input/output devices

2. Basics of scientific computing

Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods

3. Errors and error Analysis

Truncation and round off errors, Absolute and relative errors, Floating point computations.

4. Introduction to plotting graphs with Gnuplot

Basic 2D and 3D graph plotting - plotting functions and data files, fitting data using gnuplot's fit function, polar and parametric plots, modifying the appearance of graphs, Surface and contour plots, exporting plots.

5. Curve fitting, Least square fit, Goodness of fit, standard deviation

6. Ohms law to calculate R, Hooke's law to calculate spring constant

Reference Books

► Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.

► A first course in Numerical Methods, U.M. Ascher& C. Greif, 2012, PHI Learning.

► Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn . , 2007, Wiley India Edition.

► Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.

► An Introduction to Computational Physics, T.Pang, 2nd Edn., 2006,Cambridge Univ. Press

► Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd

Course Outcomes:

Developed the concept of GNU plot and basic knowledge of the error calculation, error analysis, curve fitting, exporting plots.

Core T2 – Mechanics (4 Credits)

1. Fundamentals of Dynamics

Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable- mass system: motion of rocket. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse.

2. Work and Energy

Work and Kinetic Energy Theorem. Conservative and non- conservative forces. Potential Energy. Qualitative study of one dimensional motion from potential energy curves. Stable and unstable equilibrium. Instantaneous and average power. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.

3. Rotational Dynamics

Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. Condition of pure rolling without sleeping. Ellipsoid of inertia.

4. Fluid Motion

Motion of ideal fluids. Streamlines and streamline flow. The continuity equation. Euler's equation for an incompressible fluid. Steady flow. Bernoulli's theorem and its applications for gaseous floe under isothermal and adiabatic condition. Toricelli's expression for the velocity of efflux of a liquid. Venturimeter. Kinematics of Moving Fluids, Poiseuille's Equation for Flow of a Liquid through Capillary. Working principle of Pitot tube.

5. Elasticity

Stress and strain. Hooke's law. Elastic moduli and their interrelationship. Strain-energy in a stretched wire. Strain-energy associated with a pure strain. Torsion of a wire. Torsional oscillations. Loaded beams. Bending moment. Stresses induced by bending. Beam supported at its two ends and carrying a load at any point of the beam. The cantilever. Reciprocal theorem of light cantilever. Strain and stress tensor.

6. Gravitation and Central Force Motion

Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere.

Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Energy and nature of orbits for particle motion under central force. Basic idea of global positioning system (GPS).

7. Non-Inertial Systems

Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Special Theory of Relativity

Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Length contraction. Time dilation. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect.

Reference Books

► An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.

► Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.

► Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.

► Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.

► Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education

► Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.

► University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Additional Books for Reference

► Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000

► University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley

► Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning

► Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

Course Outcomes:

1. Develop the concepts of classical mechanics and basic knowledge of the non-inertial and inertial frame of reference, variable mass, rocket motion, special theory of relativity.
2. Acquire knowledge about the elasticity of the material and the streamline and turbulent motion. Understand the relationship between elastic constants.
3. Understand how major concepts developed and changed over time.
4. Capable of analyzing and solving problems using oral and written reasoning skills based on the concepts of classical mechanics.
5. Ability to prepare and organize a presentation on the application of fundamental dynamics.

Core P2 – Mechanics Lab (2 Credits)

General topic

1. Measurements of length (or diameter) using vernier caliper, screw gauge and traveling microscope.

2. To study the random error in observations.

List of practical (Any five of the following experiments should be done)

1. To study the Motion of Spring and calculate, (a) Spring constant, (b) g and (c) Modulus of rigidity.

2. To determination of the Young's modulus of a material in the form of a bar by the method of flexure.

3. To determine the coefficient of viscosity of water by capillary flow method (Poiseuille's method).

4. Determination of the coefficient of viscosity of highly viscous liquid by Stoke's method.

5. To determine the value of g using Bar Pendulum.

6. To determine the value of g using Kater's Pendulum.

7. To determine the height of a building using a Sextant.

8. To determine the Moment of Inertia of a Flywheel.

Reference Books

► Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

► A Text Book of Practical Physics, I. Prakash& Ramakrishna, 11th Edn, 2011, KitabMahal

► Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

Course Outcomes:

1. Learn how can use the screw gauge, slide callipers, microscope, telescope.

2. Able to know how experimentally measure the Young's modulus, coefficient of viscosity of liquid, acceleration due to gravity, spring constant.

SEMESTER-II

Core T3 - Electricity and Magnetism (4 Credits)

1. Electric Field and Electric Potential

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry.

Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.

Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Uniqueness theorem (statement). Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

2. Dielectric Properties of Matter

Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between E, P and D. Gauss' Law in dielectrics.

3. Magnetic Field

Magnetic force between current elements and definition of Magnetic Field B. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole).

Ampere's Circuital Law and its application to (1) infinite straight wire, (2) Infinite planar surface current, and (3) Solenoid. Properties of B: curl and divergence. Axial vector property of B and its consequences. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.

4. Electromagnetic Induction

Faraday's Law. Lenz's Law. Self-Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current

5. Magnetic Properties of Matter

Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis.

6. Electrical Circuits

AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit

7. Network theorems

Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits

Note: For the sake of brevity, details of ballistic galvanometer may be omitted from the theory course. Some part of the theory may be needed for the experiments, but this can be covered as part of Practical.

Reference Books

► Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw

► Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education

► Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.

► Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education

► Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.

► Electricity and Magnetism, J.H.Fewkes&J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

Course Outcomes:

The course will help the students to understand the basic concepts of electrostatics including electric field, potential, electrostatic energy, electric dipole etc. They should be able to understand Laplace's equation, Poisson's equation, method of images and their application to simple electrostatic problems. The students will also acquire knowledge about dielectric properties of matter and application of laws of electrostatics for dielectric materials. This course will provide the students with basic knowledge of magnetostatics i.e. magnetic effect of current and related laws of physics. On completion of the course students will learn about electromagnetic induction, magnetic properties of matter, operation of different ac electrical circuits. They should also acquire knowledge of different network theorems.

Core P3 – Electricity and Magnetism Lab (2 Credits)

General topic

Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current,

(d) Capacitances, and (e) Checking electrical fuses.

List of Practical (Any five of the following experiments should be done)

1. To verify the Thevenin, Norton and Maximum power transfer theorems.

2. To determine self-inductance of a coil by Anderson's bridge.

3. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency,

(b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.

4. To study the response curve of a parallel LCR circuit and determine its (a) Anti- resonant frequency and (b) Quality factor Q.

5. Determination of the ECE of copper.

6. Determination of the boiling point of a suitable liquid using a platinum resistance thermometer.

7. Determination of a ballistic galvanometer constant by capacitor charging and discharging method.

8. Construction of one Ohm coil.

Reference Books

► Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House

► A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

► Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning.

► A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

Course Outcomes:

On performing the laboratory experiments students should have a rudimentary grasp on how experimental equipment related to electricity and magnetism can be used. They will have a better insight by experimentally verifying some of the laws/theorems of electricity and magnetism.

Core T4 - Waves and Optics (4 Credits)

1. Oscillations

SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.

2. Superposition of Collinear Harmonic oscillations

Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. Superposition of two perpendicular Harmonic Oscillations. Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency and their uses.

3. Wave Motion

Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Traveling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves

4. Superposition of Two Harmonic Waves

Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves.

5. Wave Optics

Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.

6. Interference

Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.

7. Interferometer

Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.

8. Diffraction and Holography

Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.
Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire. Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.

Reference Books

► Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.

► Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill

► Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.

► Optics, AjoyGhatak, 2008, Tata McGraw Hill

► The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.

► The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.

► Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.

Course Outcomes:

The course will provide the students with knowledge of various aspects of simple harmonic oscillation including damped and forced oscillations, resonance, superposition under different conditions, Lissajous figures etc. The students will acquire knowledge about wave motion, superposition of waves and formation of waves on strings and pipes. The waves and optics part will help the students to understand the wave nature of light and the phenomenon of interference as well as the principle of operation of different interferometers. The course further enables the students to understand the phenomena of diffraction (Fraunhofer and Fresnel type) and basic concepts of holography.

Core P4 – Wave and Optics Lab (2 Credits)

List of Practical (Any five of the following experiments should be done)

1. To investigate the motion of coupled oscillators.

2. To study Lissajous Figures.

3. Familiarization with: Schuster`s focusing; determination of angle of prism.

4. To determine refractive index of the Material of a prism using sodium source.

5. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.

6. To determine wavelength of sodium light using Fresnel Biprism.

7. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.

8. To determine dispersive power and resolving power of a plane diffraction grating.

Reference Books

► Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.

► Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill

► Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.

► Optics, AjoyGhatak, 2008, Tata McGraw Hill

► The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.

► The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.

► Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.

Course Outcomes:

On performing the laboratory experiments students will have hands-on experience of using experimental equipment like spectrometer. The experiments on waves and optics will further consolidate their knowledge on the subject.

SEMESTER-III

Core T5 - Mathematical Physics-II (4 Credits)

1. Complex numbers

Functions of a complex variable. Single- and multivalued functions. Analytic functions. Cauchy-Riemann equations.

2. Complex line integrals

Cauchy's integral theorem (no proof is required) for simply connected regions. Simple consequences of Cauchy's theorem. Cauchy's integral formula. The Taylor and Laurent expansions (statement only). Singular points. Removable singularity. Poles. Essential singularity. Residue at a pole of order m. Cauchy's residue theorem. Evaluation of simple integrals with the help of residue theorem.

3. Matrix algebra

Transpose of a matrix, Hermitian, orthogonal and unitary matrices. Matrix for rotation in two and three dimensions. The inverse of a matrix. Solution of a system of linear equations by matrix method. Eigenvalues and eigenvectors of a matrix. Properties of eigenvectors and eigenvalues of Hermitian and unitary matrices. Matrix representations of Linear operators. Similarity transformation.

4. Introduction to Probability

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance. Bayes' Theorem and the idea of hypothesis testing.

5. Dirac Delta function and its properties

Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.

6. Variational calculus in Physics

Functionals. Basic ideas of functionals. Extremization of action as a basic principle in mechanics. Lagrangian Formulation. Euler's equations of motion for simple systems: harmonics oscillators, simple pendulum, spherical pendulum, coupled oscillators. Cyclic coordinates. Symmetries and conservation laws. Legendre transformations and the Hamiltonian formulation of mechanics. Canonical equations of motion. Applications to simple systems.

Reference Books

► Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.

► Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.

► Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.

► Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.

► Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press

► Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

► Mathematical Physics, P. K. Chattopadhyay, 2014, New Academic Science.

Course Outcomes:

1. Students will develop the concept about Argand diagram and know the algebraic operation on complex number
2. Know about different types of singularity and able to know simplest way of integration over a closed contour.
3. Develop the idea about probability, Dirac-delta function, variational calculation, matrix algebra.

Core P5 – Mathematical Physics II Lab (2 Credits)

1. Introduction to programming in python:

Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements, lists, tuples, dictionaries and strings, basic ideas of object oriented programming**.**

2. Introduction to Computer Programming

Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search, Random number generation, Area of circle, area of square, volume of sphere, value of pi (π).

3. Introduction to Numerical Computation

Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods, Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation, Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method, Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods.

Reference books

►Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.

► Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A. Downey, 2015, Dreamtech Press.

► Introduction to computation and programming using Python, J. Guttag, 2013, Prentice Hall India.

► Effective Computation in Physics- Field guide to research with Python, A. Scopatz and

K.D. Huff, 2015, O'Rielly

► A first course in Numerical Methods, U.M. Ascher& C. Greif, 2012, PHI Learning.

► Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn . , 2007, Wiley India Edition.

► Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.

► An Introduction to Computational Physics, T.Pang, 2nd Edn., 2006,Cambridge Univ. Press

► Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd

Course Outcomes:

1. There is a scope to study the Python programming language.
2. Able to learn how can solve any physical problem in Python.

Core T6 - Thermal Physics (4 Credits)

1. Introduction to Thermodynamics

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence.

Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

2. Thermodynamic Potentials

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations

3. Maxwell's Thermodynamic Relations

Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) ClausiusClapeyron equation, (2) Values of C_p-C_v, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.

4. Kinetic Theory of Gases

Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. Molecular Collisions. Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.

5. Real Gases

Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule- Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule- Thomson Cooling.

Reference Books

► Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.

► Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill

► Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.

► Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.

► Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press

► Thermodynamics and an introduction to thermostatistics, H. B. Callen, 1985, Wiley.

► Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications

Course Outcomes:

1. Know about the kinetic of gases, zeroth low of thermodynamics, 1st and 2nd law of thermodynamics.
2. Gather knowledge about isothermal and adiabatic process and also learn how to solve the thermodynamic problems.
3. Learn about the entropy and how the entropy of the universe is changing.
4. Understand how statistics of the microscopic world can be used to explain the thermal features of the macroscopic world.
5. Be able to use thermal and statistical principles in a wide range of applications

Core P6 – Thermal Physics Lab (2 Credits)

List of Practical (Any five of the following experiments should be done)

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne’s constant flow

method.

2. To determine the Coefficient of Thermal Conductivity of Cu by Searle’s Apparatus.

3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom’s Method.

4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and

Charlton’s disc method.

5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).

6. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its Two Junctions.

7. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature

Reference Books

► Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House

► A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

► A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.

Course Outcomes:

1. Able to learn how experimentally measure the thermal conductivity in different methods.

2. Also learn about the platinum resistance thermometer, thermocouple etc.

Core T7 - Analog Systems and Applications (4 Credits)

1. Semiconductor Diodes

P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode.

2. Two-terminal Devices and their Applications

Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell.

3. Bipolar Junction transistors

n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.

4. Field Effect transistors

Field effect transistor – JEET and its IV characteristics, pinch-off voltage, applications. MOSFET – structure, classification of MOSFETs, enhancement and depletion types, typical applications; structure, I-V characteristics.

5. Amplifiers

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. Frequency response of a CE amplifier.

Coupled Amplifier: Two stage RC-coupled amplifier.

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.

Applications of Op-Amps: Linear - (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator. Non-linear – (1) inverting and non-inverting comparators, (2) Schmidt triggers.

Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation)

6. Communication electronics:

Introduction. Need for modulation. Block diagram of an electronic communication system.

Reference Books

► Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.

► Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.

► Solid State Electronic Devices, B.G.Streetman &S.K.Banerjee, 6th Edn.,2009, PHI Learning

► Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill

► OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall

► Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.

► Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer

► Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India

► Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning

► Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

Course Outcomes:

This course will help the students to get familiar with different topics of semiconductor physics. They will come to know about the characteristics and various applications of diodes, bipolar transistors and field effect transistors. The students will come to know about the operational amplifier and its uses in different aspects.

3.18 Core P7 – Analog Systems and Applications Lab (2 Credits)

List of Practical (Any five of the following experiments should be done)

1. To study the characteristics of a Bipolar Junction Transistor in CE configuration and designing a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.

2. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.

3. To design a Wien bridge oscillator for given frequency using an op-amp.

4. To design a digital to analog converter (DAC) of given specifications.

5. To design inverting amplifier andnon-inverting using Op-amp (741,351) for dc voltage of given gain.

6. To design inverting amplifier and non-inverting amplifier using Op-amp (741,351) and study its frequency response

7. To study the zero-crossing detector and comparator

8. To investigate the use of an op-amp as adder in inverting and non-inverting mode, Differentiator and Integrator.

Reference Books

► Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.

► OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.

► Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.

► Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson

Course Outcomes:

This course will help the students to get familiar experimental experience with different topics of semiconductor physics. They will come to know about the characteristics and various applications of diodes, bipolar transistors and field effect transistors using electronics components. The students will come to know about the operational amplifier and its uses in different aspects by preparing electronic circuit.

SEMESTER-IV

Core T8 - Mathematical Physics III (4 Credits)

1. **Linear Vector Spaces**

Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices.

Inner products. Gram-Schmidt orthogonalization. Orthogonal and unitary transformations and their matrix representations.

2. **Integrals Transforms**

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations

Laplace Transform: LT of Elementary functions. Properties of LTs, Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.

3. **Eigen-values and Eigenvectors**

Cayley- Hamilton Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a Matrix.

Reference Books

► Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press

Core P8 – Mathematical Physics III Lab (2 Credits)

List of Practical (Any five of the followings should be done)

1. Solve differential equations:

$$\frac{dy}{dx} = e^{-x}\ with\ y = 0\ for\ x = 0$$

$$\frac{dy}{dx} + e^{-x} = x^2$$

$$\frac{d^2y}{dt^2} + 2\frac{dy}{dt} = -y$$

$$\frac{d^2y}{dt^2} + e^{-t}\frac{dy}{dt} = -y$$

2. Dirac Delta Function: Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}}\int e^{-\frac{(x-2)^2}{2\sigma^2}}(x+3)dx$, for σ=1, 0.1, .01 and show it tends to 5.
3. Fourier Series: Program to sum$\sum_{n=1}^{\infty}(0.2)^n$, Evaluate the Fourier coefficients of a given periodic function (square wave).
4. Frobenius method and Special functions:

$\int_{-1}^{1} P_n(\mu)P_m(\mu)d\mu = \delta_{n,m}$

Plot $P_n(x), j_v(x)$

Show recursion relation.

5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).

6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.

7. Evaluation of trigonometric functions e.g. sin θ, Given Bessel's function at N points find its value at an intermediate point. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration

8. Compute the nth roots of unity for n = 2, 3, and 4.

9. Find the two square roots of −5+12j.

10. Integral transform: FFT of e^{-x2}

Reference Books

► Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press

► Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications

► Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896

► A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press

Course Outcomes:

Mathematical Physics plays a very important role in the course of Physics. In almost all branches of Physics, Mathematics is used as a tool for analyzing various physical problems. From this course the students will able to gather knowledge regarding Linear Vector Space, Integral transformations and Eigen value problems.

3.16 Core T9 – Elements of Modern Physics (4 Credits)

1. Unit 1

Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions.

2. Unit 2

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction. Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for nonrelativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.

3. Unit 3

One dimensional infinitely rigid box- energy eigenvalues and eigen functions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension across a step potential & rectangular potential barrier.

4. Unit 4

Size and structure of atomic nucleus and its relation with atomic weight; Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers.

5. Unit 5

Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.

6. Unit 6

Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).

7. Unit 7

Lasers: Einstein’s A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing.

Reference Books

► Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.

► Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill

► Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.

► Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.

► Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill

► Quantum Mechanics: Theory & Applications, A.K.Ghatak&S.Lokanathan, 2004, Macmillan

Additional Books for Reference

► Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.

► Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.

► Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.

► Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.

► Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

Course Outcomes:

From this course the students will learn about the black body radiation and the failure of classical theory to explain the characteristics of black body radiation. Then they will be acquainted with the basics of Quantum mechanics. They will learn how the Schrodinger equation is applied to solve physical problems with simple potentials. Students will also learn about the static properties of atomic nuclei, radioactivity, fission and fusion. Students will also learn the basic theory of LASER after completing this course.

3.19 Core P9 –Modern Physics Lab (2 Credits)

List of Practical (Any five of the following experiments should be done)

1. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light

2. To determine work function of material of filament of directly heated vacuum diode.

3. To determine the wavelength of H-alpha emission line of Hydrogen atom.

4. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.

5. To setup the Millikan oil drop apparatus and determine the charge of an electron.

6. To determine the wavelength of laser source using diffraction of single slit.

7. To determine the wavelength of laser source using diffraction of double slits.

8. To determine the Boltzmann constant using I-V characteristics of PN junction diode

Reference Books

► Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

► A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Edn, 2011,Kitab Mahal

Core T10 - Digital Systems and Applications (4 Credits)

1. Integrated Circuits

Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs.

2. Digital Circuits

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.

Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip- Flop.

Timers IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator.

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).

Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

Reference Books

► Digital Principles and Applications, A.P. Malvino, D. P. Leach and Saha, 7th Ed., 2011, Tata McGraw
► Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
► Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
► Digital Electronics G K Kharate ,2010, Oxford University Press
► Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
► Logic circuit design, Shimon P. Vingron, 2012, Springer.
► Digital Electronics, SubrataGhoshal, 2012, Cengage Learning.
► Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
► Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar,

Prentice Hall.

Course Outcomes:

Develop the concept about the active and passive circuit elements and how they work in circuit. Acquire knowledge about the different types of digital circuit such as combinational and sequential and their implementation using diode and transistor. Get clear knowledge about the different types of memory elemts, 555 timer, A-stable multivibrator, bi-stable multivibrator, mono-stable.

Core P10 – Digital Systems and Applications Lab (2 Credits)

General topic

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.

2. To test a Diode and Transistor using a Multimeter.

List of Practical (Any five of the following experiments should be done)

1. To design a switch (NOT gate) using a transistor.

2. To verify and design AND, OR, NOT and XOR gates using NAND gates.

3. To design a combinational logic system for a specified Truth Table.

4. To convert a Boolean expression into logic circuit and design it using logic gate ICs.

5. Half Adder, Full Adder and 4-bit binary Adder.

6. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.

7. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.

8. To design an astable multivibrator of given specifications using 555 Timer.

9. To design a monostable multivibrator of given specifications using 555 Timer.

Reference Books

► Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.

► Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.

Course Outcomes:

1. Learn to design the electronic circuit in hand.

2. Get opportunity to study the Fliop-Flop, 555-timer, different combinational circuit.

SEMESTER-V

3.20 Core T11 - Quantum Mechanics and Applications (4 Credits)

1. Schrodinger Equation

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; The Schrodinger equation in two and three dimensions. Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigen functions. The operator formalism in quantum mechanics, Fundamental operators in quantum mechanics. Introduction of the bra-ket notations. Hermitian operators, simultaneous eigen functions. Commutation relations of fundamental operators. Expectation values. Wave Function of a Free Particle.

Time independent Schrodinger equation: Separation of variables. Hamiltonian, stationary states and energy eigen values; expansion of an arbitrary wave function as a linear combination of energy eigen functions; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wave function; Position-momentum uncertainty principle.

2. General discussion of bound states in an arbitrary potential

continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem- square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigen functions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.

3. Quantum theory of hydrogen-like atoms

Time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; Angular momentum operator & Quantum numbers; Angular momentum commutation relation; Radial wave functions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d shells.

4. Atoms in Electric & Magnetic Fields

Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor’s Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.

5. Atoms in External Magnetic Fields

Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only).

6. Many electron atoms

Pauli's Exclusion Principle. Symmetric & Anti-symmetric Wave Functions. Periodic Table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms- L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.).

Reference Books

► A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill

► Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.

► Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.

► Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.

► Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

► Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer

► Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

Additional Books for Reference

► Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.

► Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education

► Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

► Introductory Quantum Mechanics by Gasiorowicz.

► Quantum Mechanics; Volume 1, Cohen-Tannoudji

Course Outcomes:

Introduction of notations and matrix formulation and extension in three dimensions in some more cases will increase the understanding in Quantum Mechanics to a better level. The point-wise mention in respect of potential will help to get the extent of syllabus for a particle. More reference books are added for better insight of knowledge.

Core P11 – Quantum Mechanics and Applications Lab (2 Credits)

List of Practical (Any five of the following experiments should be done)

1. To determine the ionization potential of mercury.

2. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency.

3. Study of Spectra of Hydrogen to calculate Rydberg Constant.

4. Study of Zeeman effect: with external magnetic field; Hyperfine splitting

5. To show the tunneling effect in tunnel diode using I-V characteristics.

6. To determine the quantum efficiency of CCDs.

7. Measurement of Planck's constant using black body radiation and photo-detector.

8. To determine the Planck's constant using LEDs of at least 4 different colours.

9. To determine the absorption lines in the rotational spectrum of Iodine vapour.

Reference Books

► OCTAVE and SCILAB: Scientific &

► Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández.2014 Springer.

Course Outcomes:

An additional practical by introducing "Calculation for Rydberg Constant using Hydrogen spectra" may help to compare the spectra formulated in Hydrogen atom model in quantum mechanics and Quantum theory.

Core T12 - Solid State Physics (4 Credits)

1. Crystal Structure

Solids: Amorphous and Crystalline Materials. Nature of bonding in Crystalline solids. Cohesive Energy of ionic and metallic crystals. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell & Primitive cell, Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor.

2. Elementary Lattice Dynamics

Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law.

3. Magnetic Properties of Matter

Origin of magnetism, Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia-magnetism and para-magnetism; Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

4. Dielectric Properties of Materials

Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. ClausiusMosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes.

5. Ferroelectric Properties of Materials

Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.

6. Elementary band theory

Bloch Theorem, Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient. Application in PV cell.

7. Superconductivity

Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

Reference Books

► Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.

► Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India

► Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill

► Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning

► Solid-state Physics, H. Ibach and H. Luth, 2009, Springer

► Solid State Physics, Rita John, 2014, McGraw Hill

► Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India

► Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Course Outcomes:

The syllabus is neither extended nor revised in an extreme significant order. Some points are inserted for step by step advancement minimizing less diversion e.g. Unit Cell with Primitive Cell, symmetry then Brillouin Zone etc. Understanding of quantization of acoustical energy in addition to quantization of optical energy is reflected along a comparative avenue with experimental observations. The infusion of quantization in magnetism leads the molecular magnetic theory from classical to quantum. Similarly, the electrostatics is exposed to the students. The Elementary Band theory part is also ornamented with some more words for initiation of

‘Band theory with generation based application’ along a mathematical passage after 10+2 level.

Core P12 – Solid State Physics Lab (2 Credits)

List of Practical (Any five of the following experiments should be done)

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)

2. To measure the Magnetic susceptibility of Solids.

3. To determine the Coupling Coefficient of a Piezoelectric crystal.

4. To measure the Dielectric Constant of a dielectric Materials with frequency

5. To determine the refractive index of a dielectric layer using SPR

6. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.

7. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to $150^{o}C$) and to determine its band gap.

8. To determine the Hall coefficient of a semiconductor sample.

9. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)

10. To study the PE Hysteresis loop of a Ferroelectric Crystal.

Reference Books

► Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

► A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal

► Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

Course Outcomes:

Theoretical study will remain as literature unless experimental observation. The Experiments for Lab are mostly selected in such a manner so that evolution of curiosity in theoretical classes may be normalized to a certain extent considering overall situation (mainly maintenance scope in some areas) of HEIs.

SEMESTER-VI

Core T13 - Electromagnetic Theory (4 credits)

1. Maxwell Equations

Maxwell’s equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density.

2. EM Wave Propagation in Unbounded Media

Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.

3. EM Wave in Bounded Media

Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence)

4. Polarization of Electromagnetic Waves

Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel’s Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light Rotatory Polarization: Optical Rotation. Biot’s Laws for Rotatory Polarization. Fresnel’s Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel’s theory. Specific rotation. Laurent’s half-shade polarimeter.

Electro-optic and magneto-optic effects: Faraday effect. Verdet’s constant. Kerr effect. Kerr cell as a fast optical shutter. Use of a Kerr cell in the determination of the speed of light. Pockels effect.

5. Wave guides

Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission.

6. Optical Fibres

Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only).

Reference Books

► Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.

► Optics, E. Hecht, 2016, Pearson.

► Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.

► Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning

► Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill

► Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning

► Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.

► Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Additional Books for Reference

► Electromagnetic Fields & Waves, P.Lorrain&D.Corson, 1970, W.H.Freeman& Co.

► Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.

► Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004,Cambridge University Press

Course Outcomes:

This course will help the students to get familiar with different topics of Electromagnetic theory. They will learn the Maxwell's equations and different consequences derived from these equations. Students will learn the theory of EM wave propagation through unbounded and bounded media. They will come to know about the polarization of EM wave and various electro-optic and magneto optic effects. They will also get acquainted with the wave guides and optical fibres.

Core P13 – Electromagnetic Theory Lab (2 Credits)

List of Practical (Any five of the following experiments should be done)

1. To verify the law of Malus for plane polarized light.

2. To determine the specific rotation of sugar solution using Polarimeter.

3. To analyze elliptically polarized Light by using a Babinet's compensator.

4. To study the reflection, refraction of microwaves

5. To study Polarization and double slit interference in microwaves.

6. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.

7. To verify the Stefan`s law of radiation and to determine Stefan's constant.

8. To study dependence of radiation on angle for a simple Dipole antenna.

9. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.

10. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.

11. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.

Reference Books

► Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

► A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, KitabMahal

► Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Core T14 – Statistical Mechanics (4 Credits)

1. Classical Statistical Mechanics

Macrostate & Microstate, Elementary Concept of Ensemble, Microcanonical ensemble, Phase Space, Entropy and Thermodynamic Probability, Canonical ensemble, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, SackurTetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. Grand canonical ensemble and chemical potential.

2. Classical Theory of Radiation

Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's

Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe.

3.Quantum Theory of Radiation

Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.

4.Bose-Einstein Statistics:

B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.

5.Fermi-Dirac Statistics:

Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.

Reference Books

►Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed.,1996, Oxford University Press.

► Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill

► Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice HallThermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.

► Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer

► An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

► Statistical Mechanics – an elementary outline, A. Lahiri, 2008, Universities Press

Course Outcomes:

While going through this course, the students will learn the classical statistical mechanics and classical theory of radiation. They will come to know the quantum theory of radiation. Finally the students will get familiar with Bose-Einstein statistics, Fermi-Dirac statistics and their different applications.

Core P14 – Statistical Mechanics Lab (2 Credits)

List of Practical (any four of the following experiments should be done)

1. Computational analysis of the behaviour (any three) of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:

a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations

b) Study of transient behavior of the system (approach to equilibrium)

c) Relationship of large N and the arrow of time

d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution

e) Computation and study of mean molecular speed and its dependence on particle mass

f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed

2. single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose- Einstein statistics:

a) volume Cv, depend upon the temperature, total number of particles N and the spectrum of single particle states.

b) Ratios of occupation numbers of various states for the systems considered above

c) Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.

3. Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.

4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.

5. Plot the following functions with energy at different temperatures

a) Maxwell-Boltzmann distribution

b) Fermi-Dirac distribution

c) Bose-Einstein distribution

Reference Books

► Elementary Numerical Analysis, K.E.Atkinson, 3 rdEdn . 20 07 , Wiley India Edition

► Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.

► Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987

► Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.

► Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.

► Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896

4. Department Specific Electives Subjects Syllabus

SEMESTER-V

4.1 DSE T1 - Advanced Mathematical Physics (6 Credits)

1. Cartesian Tensors

Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti- symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. Angle Between Lines.

Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law.

2. General Tensors

Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.

3. Group Theory

Review of sets, Mapping and Binary Operations, Relation, Types of Relations.

Groups: Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Co-sets of a subgroup, cyclic group, Permutation/Transformation. Homomorphism and Isomorphism of group. Normal and conjugate subgroups, Completeness and Kernel.

Some special groups with operators. Matrix Representations: Reducible and Irreducible representations. Schur's lemma. Orthogonality theorems. Character tables and their uses. Application to small vibrations.

4. Advanced Probability Theory:

Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, Repeated

Trials, Binomial and Multinomial expansions. Random Variables and probability distributions, Expectation and Variance, Special Probability distributions: The binomial distribution, The Poisson distribution, Continuous distribution: The Gaussian (or normal) distribution, The principle of least squares.

Reference Books

► A student's Guide to Vectors and Tensors, Daniel Fleisch, S.Chand,2012

► Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press

► Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

► Mathematical Physics, P. K. Chattopadhyay, 2014, New Academic Science.

- MATRICES AND TENSORS IN PHYSICS,A.W.Joshi, 4th Edition, New Age International.
- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- Mathematical Physics, H.K. DAAS & DR. RAMA VERMA,2019, S Chand.
- Group Theory for Physicists, Pichai Ramadevi & Varun Dubey, Cambridge University Press
- Elements of Group Theory for Physicists, A W Joshi, New Age International.
- Probability and Statistics for Engineering and the Sciences, Jay L. Devore, 2020, Cengage India Private Limited.
- Lectures on Advanced Mathematical Methods for Physicists TRiPS 9, 2014, Sunil Mukhi & N. Mukunda, Hindustan Book Agency.

Course Outcomes:

Transformation of Co-ordinates in 10+2 level to Isotropic Tensor in support of calculaus and vectors helps the students to understand Cartesian Tensors and application in physical properties like elasticity as a different essence of physics. The General Tensor, Group Theory and Probability theory to the advance level will help in penetrating into the higher studies as well as to appear in Grade-1 competitive examinations.

DSE T2 - Classical Dynamics (6 Credits)

1. Classical Mechanics of Point Particles

Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyrofrequency, motion in crossed electric and magnetic fields. Generalized coordinates and velocities,

Recap of Lagrangian and Hamiltonian mechanics. Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy. Effective potential. The Laplace-Runge-Lenz vector.

2. Small Amplitude Oscillations

Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N -1) -identical springs.

3. Special Theory of Relativity

Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle.

4. Fluid Dynamics

Fluid, an element of fluid and its velocity, Navier-Stokes equation, qualitative description of turbulence, Reynolds number.

Reference Books

► Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
► Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books
► Mathematical Physics, P. K. Chattopadhyay, 2014, New Academic Science.
- MATRICES AND TENSORS IN PHYSICS,A.W.Joshi, 4th Edition, New Age International.
- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- Mathematical Physics, H.K. DAAS & DR. RAMA VERMA,2019, S Chand.
- Classical Dynamics: A Modern Perspective, Sudarshan & Mukunda, HINDUSTAN BOOK AGENCY, World Scientific.

Course Outcomes:

The syllabus formulation has been done considering the aspects of both microscopic particle and macroscopic particle. The approach is made parallel for stimulating fields - Gravitational, Magnetic and Electric. Small oscillation and normal modes considering spring model is a simple way to know matter especially solid. Lorentz transformation to knowledge of relativity in tensor will help to better understand the dynamics of particle including two-body decay in an unstable particle.

DSE T3 - Nuclear and Particle Physics (6 Credits)

1. General Properties of Nuclei

Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.

2. Nuclear Models

Liquid drop model approach, experimental evidence of liquid drop model of nucleus, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), Experimental evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.

3. Radioactivity decay

(a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α---decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion.

4. Nuclear Reactions

Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).

5. Interaction of Nuclear Radiation with matter

Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.

6. Detector for Nuclear Radiations

Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

7. Particle Accelerators

Introduction of accelerator. Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons, Betatron. Accelerator facility available in India

6. Particle physics

Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, concept of colour charge and gluons.

Reference Books:

► Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
► Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
► Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004)
► Introduction to Elementary Particles, D. Griffith, John Wiley & Sons

Course Outcomes:

Recapitulation of general idea of nucleus in respect of binding energy and extended to various nuclear models may grow interest for minute particles and their behaviours. Radioctive decay and nuclear reactions in controlled procedure including interaction of radiation with matter, the syllabus for necessary instruments may the completeness condition to a significant level of a student for becoming nuclear-personnel expert.

DSE T4 - Astronomy and Astrophysics (6 Credits)

1. Astronomical Scales

Astronomical Distance, Mass and Time, Scales, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature. Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram.

2. Astronomical techniques

Basic Optical Definitions for Astronomy (Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes) Physical principles

Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium.

3. The sun and solar family

The sun (Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics. Helioseismology). The solar family (Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets.

Stellar spectra and classification Structure (Atomic Spectra Revisited, Stellar Spectra, Spectral

Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification)

4. The milky way

Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus.

5. Galaxies

Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms

6. Large scale structure & expanding universe

Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter).

Reference Books

► Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.

► Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory,4th Edition, Saunders College Publishing.

► The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.

► Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer

► K.S. Krishnasamy, 'Astro Physics a modern perspective,' Reprint, New Age International

(p) Ltd, New Delhi,2002.

► BaidyanathBasu, 'An introduction to Astro physics', Second printing, Prentice - Hall of India Private limited, New Delhi, 2001.

► Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

Course Outcomes:

Long awaited curiosity of students in astronomical measurements of Distance, mass and time. Knowledge in stellar spectral classification knowing various astronomical detectors and techniques will open a new channel for higher studies in Astro-Physics.

SEMESTER-VI

DSE T5 – Physics of Earth (6 Credits)

1. The Earth and the Universe

Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences.

General characteristics and origin of the Universe. The Milky Way galaxy, solar system, Earth's orbit and spin, the Moon's orbit and spin. The terrestrial and Jovian planets. Meteorites & Asteroids. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age. Energy and particle fluxes incident on the Earth. The Cosmic Microwave Background.

2. Structure

The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field,

geothermal energy. How do we learn about Earth's interior?

The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems.

The Atmosphere: variation of temperature, density and composition with altitude, clouds.
The Cryosphere: Polar caps and ice sheets. Mountain glaciers.

The Biosphere: Plants and animals. Chemical composition, mass. Marine and land organisms.

3. Dynamical Processes

The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Volcanoes: types products and distribution.

The Hydrosphere: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of eustasy, tend– air-sea interaction; wave erosion and beach processes. Tides. Tsunamis.

The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heatbudget. Cyclones.

Climate: Earth's temperature and greenhouse effect. Paleoclimate and recent climate changes.

The Indian monsoon system.

Biosphere: Water cycle, Carbon cycle, Nitrogen cycle, Phosphorous cycle. The role of cycles in maintaining a steady state.

4. Evolution

Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods in their application in geological studies. History of development in concepts of uniformitarianism, catastrophism and neptunism. Law of superposition and faunal succession. Introduction to the geology and geomorphology of Indian subcontinent.

Time line of major geological and biological events. Origin of life on Earth.

Role of the biosphere in shaping the environment.

Future of evolution of the Earth and solar system: Death of the Earth.

5. Disturbing the Earth – Contemporary dilemmas

1. Human population growth.

2. Atmosphere: Greenhouse gas emissions, climate change, air pollution.

3. Hydrosphere: Fresh water depletion.

4. Geosphere: Chemical effluents, nuclear waste.

5. Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

Reference Books

► Planetary Surface Processes, H. Jay Melosh, Cambridge University Press, 2011.

► Consider a Spherical Cow: A course in environmental problem solving, John Harte. University Science Books

► Holme's Principles of Physical Geology. 1992. Chapman & Hall.

► Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.

Course Outcomes:

Through this course, the students will know about the earth and the universe. They will know about the structure of the earth. The will get familiar with the dynamical processes and the evolution process undergone since the formation of earth. The students will also get the opportunity to study on the contemporary issues that are disturbing the earth.

DSE T6 – Biological Physics (6 Credits)

1. Overview

The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales. Universality of microscopic processes and diversity of macroscopic form. Types of cells. Multicellularity. Allometric scaling laws.

2. Molecules of life

Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling.

Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell.

Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways. Random walks and applications to biology. Mathematical models to be studied analytically and computationally.

3. The complexity of life

At the level of a cell: The numbers of distinct metabolites, genes and proteins in a cell. Complex networks of molecular interactions: metabolic, regulatory and signaling networks. Dynamics of metabolic networks; the stoichiometric matrix. Living systems as complex organizations; systems biology. Models of cellular dynamics. The implausibility of life based on a simplified probability estimate, and the origin of life problem.

At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cell types as distinct attractors of a dynamical system. Stem cells and cellular differentiation. Pattern formation and development.

Brain structure: neurons and neural networks. Brain as an information processing system. Associative memory models. Memories as attractors of the neural network dynamics.

At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and self- sustaining ecosystems.

4. Evolution

The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples.

Reference Books

► Physics in Molecular Biology; Kim Sneppen& Giovanni Zocchi (CUP 2005)

► Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman & Co, NY, 2004)

► Physical Biology of the Cell (2nd Edition), Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013)

► An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)

► Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition)

Course Outcomes:

While going through this course, the students will learn about the boundary, interior and exterior environment of living cells and the types of cells. They will acquire knowledge about different metabolites. Students will also come to know about the complexity of life and the evolution process.

DSE D1- Dissertation

Documentation and presentation on Project work/Field work

Course Outcomes:

This course will improve the communication skill and motivate the students for higher studies and research.

DSE T7 – Nano Materials and Applications (4 Credits)

1. Nanoscale Systems

Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nano dots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Concept of Quantum confinement, Quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences. Applications of Schrodinger equation for Infinite potential well, potential step, potential box, Effects of size reduction and high surface to volume ratio in nano systems.

2. Synthesis of Nanostructure Materials

Concept of homogeneous and heterogeneous nucleation (brief semi-qualitative discussions), Top down and Bottom up approach, Photolithography, Ball milling, Gas phase condensation, Sputtering, Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition, Chemical vapor deposition (CVD), Sol-Gel, Electrodeposition. Spray pyrolysis, Hydrothermal synthesis, Preparation through colloidal methods, MBE growth of quantum dots.

3. Characterization

X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy.

4. Optical Properties

Quantitative treatment of quasi-particles and excitons, Excitons in direct and indirect band gap semiconductor nanocrystals, Optical Absorption, Brus equation, Surface Plasmon Resonance (SPR) in metal nanoparticles. Radiative processes: emission and luminescence. Optical properties of core-shell nanostructures.

5. Electron Transport

Carrier transport in nanostrucutures, Diffusive and ballistic transport, Coulomb blockade effect, thermionic emission, tunneling and hopping conductivity. Types of defects and impurities, Deep level and surface defects.

6. Applications

Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots -magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS). Hazardous effects of nanoparticle exposure to environment.

Reference Books

► C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).

► S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)

► K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).

► Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

► M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).

► Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.

► Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).

Course Outcomes:

Study of nanomaterials has emerged as one of the most important branch of Physics of late. While going through this course the students will learn about the nanoscale systems and their properties. They will get familiar with different synthesis and characterization techniques of various nanoscale systems. Students will also acquire knowledge regarding the optical and electrical properties of nanomaterials. They will also come to know about the various applications of nanomaterials in the diversified fields of science and technology.

DSE P7 - Nano Materials and Applications Lab (2 Credits)

List of practical (any five experiments should be done)

1. Synthesis of any metal nanoparticles employing the chemical route.

2. Synthesis of semiconductor nanoparticles employing chemical route.

3. To analyze a given set of surface plasmon resonance pattern of any metal nanoparticles of different sizes for assessing the dependence of resonance energy and peak width upon the size of the nanoparticles. (Hard copy of at least 5 spectra for different nanoparticle sizes containing proper scale is to be supplied to the students. Size of nanoparticles for each spectrum should be mentioned.)

4. To Calculate the band gap of any semiconductor nanomaterial from a given absorption/transmission spectrum. (Transmission/absorption spectrum of any semiconductor nanoparticles is to be supplied to the students.)

5. To study the given XRD pattern of any nanoparticle sample and to calculate the particle size of the sample employing Debye-Scherrer method and also to calculate the dislocation density present in the sample. (Hard copy of XRD spectra of a nanomaterial sample with proper scale is to be supplied to the students.)

6. To study the given XRD pattern of any nanoparticle sample and calculate the particle size and lattice strain of the sample employing Williamson-Hall plot. (XRD spectra with proper scale for a nanoparticle sample is to be supplied to the students.)

7. To study the given XRD pattern of any nanoparticle sample and to calculate the lattice constant of the sample employing Nelson-Relay plot. (XRD spectra with proper scale for a nanoparticle sample having cubic structure is to be supplied to the students.)

8. To study the given set of band edge fluorescence spectra of any semiconductor nanoparticles of different sizes for studying the dependence of emission energy and fluorescence peak width upon the size of the nanoparticles. (At least 5 spectra for different nanoparticle sizes containing proper scale is to be supplied to the students. Students will calculate the sizes of nanoparticles for each spectrum using the blue shift.)

Reference Books

► C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).

► S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).

► K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience & Technology (PHI Learning Private Limited).

► Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

DSE T8 - Communication Electronics (4 Credits)

1. Electronic communication

Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio.

2. Analog Modulation

Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver Analog Pulse Modulation

Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.

3. Digital Pulse Modulation

Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK).

4. Introduction to Communication and Navigation systems

Satellite Communication– Introduction, need, Geosynchronous satellite orbits geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink Mobile Telephony System – Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only).

GPS navigation system (qualitative idea only)

DSE P8 – Communication Electronics Lab (2 Credits)

List of Practical (Any five experiments should be done)

1. To design an Amplitude Modulator using Transistor

2. To study envelope detector for demodulation of AM signal

3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing (TDM)
7. To study Pulse Amplitude Modulation (PAM)
8. To study Pulse Width Modulation (PWM)
9. To study Pulse Position Modulation (PPM)

Reference Books

► Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.

► Electronic Communication system, Blake, Cengage, 5th edition

Course Outcomes:

While going through the course, the students will learn about electronic communication system. They will come to know about the analog modulation and digital pulse modulation. They will be familiar with the communication and navigation systems.

DSE T9 - Nonlinear Dynamics (4 credits):

1. Basics of Nonlinear Dynamics:

Dynamical System, constants of motion, phase space, fixed points. Nonlinear dynamical systems in Physics, biology, engineering, etc. Dynamical equations and Stability for linear systems. Flow defined by nonlinear systems of ODEs, linearization and stable manifold theorem. Hartman-Grobman theorem. Stability and Lyapunov functions. Planar flows: saddle point, nodes, foci, centers and nonhyperbolic critical points. Bifurcation theory: saddle-node, pitch-fork, Hopf, period doubling, homoclinic bifurcations. Applications in: Laser model, population dynamics.

2. Limit Cycles and Chaos:

Limit cycle oscillations and Chaos: Concept of limit cycle, Poincare-Bendixon theorem; role of nonlinearity: From harmonic oscillator to Van der Pol oscillator, Chaos, Lorenz equation and Rossler equation. Applications in: Chaos in electronic oscillators, chaos in Laser system.

3. Discrete Maps:

Discrete time nonlinear systems: logistic map, sine circle map, linear stability analysis and the existence of 2-cycles; numerical analysis of the logistic map; universality and the Feigenbaum numbers; bifurcation and chaos, intermittency, crises; Applications in: population dynamics, discrete phase-locked loop system, power electronics.

Reference Books

➢ Steven Strogatz, Nonlinear Dynamics and Chaos, 2nd Edition: With Applications to

Physics, Biology, Chemistry, and Engineering: With Applications to Physics, Biology,

- ➢ Debabrata Biswas and Tanmoy Banerjee: "Time-Delayed Chaotic Dynamical Systems: From Theory to Electronic Experiment", Springer-Nature, 2018.
- ➢ A Studies on Optical Soliton: Abhijit Sinha, INSC Publication House (IPH).

DSE P9 - Nonlinear Dynamics Lab (2 credits):

List of Practical (Any five experiments should be done)

1. Studies on van der Pol oscillator: Sinusoidal and relaxation oscillations
2. Studies of nonlinear electronic circuits and design of chaotic electronic oscillator
3. Study on op-amp based linear and nonlinear amplifier
4. Studies on time-delay based chaotic and hyperchaotic oscillators,
5. Experimental evidence of synchronization of chaos in electronic circuits,
6. Effect of Low-Pass Filtering in coupled van der Pol oscillators

Course Outcomes:

While going through the course, the students will learn about the most recent topic of nonlinear science and their applications in real world including physics, chemistry, biology, etc. This is an interdisciplinary course and enrich students to grab the whole of the science through it. They will learn different phase space analysis, bifurcation analysis and intense numerical applications through computer programming.

5. Skill Enhancement Course

SEMESTER-III

SEC T1 - Computational Physics (2 Credits)

1. Introduction

Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of linux as an Editor. Algorithms and Flowcharts: Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

2. Scientific Programming

Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.

3. Control Statements

Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical IF, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DO- WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

4. Programming

1. Exercises on syntax on usage of FORTRAN

2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.

3. To print out all natural even/ odd numbers between given limits.

4. To find maximum, minimum and range of a given set of numbers.

5. Calculating Euler number using exp(x) series evaluated at x=1

5. Scientific word processing: Introduction to LaTeX

TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.

6. Visualization

Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

Hands on exercises

1. To compile a frequency distribution and evaluate mean, standard deviation etc.

2. To evaluate sum of finite series and the area under a curve.

3. To find the product of two matrices

4. To find a set of prime numbers and Fibonacci series.

5. To write program to open a file and generate data for plotting using Gnuplot.

6. Plotting trajectory of a projectile projected horizontally.

7. Plotting trajectory of a projectile projected making an angle with the horizontally.

8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.

9. To find the roots of a quadratic equation.

10. Motion of a projectile using simulation and plot the output for visualization.

11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.

12. Motion of particle in a central force field and plot the output for visualization.

Reference Books

► Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.

► Computer Programming in Fortran 77”. V. Rajaraman (Publisher: PHI).

► LaTeX–A Document Preparation System”, Leslie Lamport (Second Edition, Addison-Wesley, 1994).

► Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)

► Schaum’s Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.

► Computational Physics: An Introduction, R.C. Verma, et al. New Age International Publishers, New Delhi(1999)

► A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning

► Elementary Numerical Analysis, K.E. Atkinson, 3 rdEdn., 2007, Wiley India Edition

5.2 SEC T2 – Renewable Energy and Energy Harvesting (2 Credits)

1. Fossil fuels and Alternate Sources of energy

Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.

2. Solar energy

Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

3. Wind Energy harvesting

Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

4. Ocean Energy

Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices.

Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

5. Geothermal Energy

Geothermal Resources, Geothermal Technologies

6. Hydro Energy

Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

7. Piezoelectric Energy harvesting

Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power

8. Electromagnetic Energy Harvesting

a. Linear generators, physics mathematical models, recent applications

b. Carbon captured technologies, cell, batteries, power consumption

c. Environmental issues and Renewable sources of energy, sustainability.

9. Demonstrations and Experiments

a. Demonstration of Training modules on Solar energy, wind energy, etc.

b. Conversion of vibration to voltage using piezoelectric materials

c. Conversion of thermal energy into voltage using thermoelectric modules.

Reference Books

► Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi

► Solar energy - M P Agarwal - S Chand and Co. Ltd.

► Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.

► Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford

University Press, in association with The Open University.

► Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009

► J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).

► http://en.wikipedia.org/wiki/Renewable_energy

Course Outcomes:

1. Able to know about the non-conventional ,conventional energy source
2. Know about the need of renewable energy source.
3. Develop the idea about tidal energy, wind energy, geothermal energy, tidal energy, solar

energy etc.

4. Understand the how can utilize the effect of the piezoelectric effect.
5. Acquire the complete knowledge about the solar pond and its important in cold country.
6. Know the import ants of the energy harvesting.

SEMESTER-IV

5.3 SEC T3 – Radiation Safety (2 Credits)

1. Basics of Atomic and Nuclear Physics

Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, the composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half-life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission.

2. Interaction of Radiation with matter: Types of Radiation

Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, Interaction of Photons - Photo- electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, Interaction of Charged Particles: Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung), Interaction of Neutrons- Collision, slowing down and Moderation.

3. Radiation detection and monitoring devices: Radiation Quantities and Units

Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Gieger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry.

4. Biological effects of ionizing radiation

Biological damage under exposure of ionizing radiation, Mechanisms of radiation damage, Determinants of biological effects: rate of absorption, area exposed, variation in species and individual sensitivity, variation in cell sensitivity, Types of radiation damage: stochastic and deterministic effects, Radiation sickness and its phases.

5. Radiation safety management

Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management.

6. Application of nuclear techniques

Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterization, Food preservation.

Experiments

1. Study the background radiation levels using Radiation meter

2. Characteristics of Geiger Muller (GM) Counter:

3. Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).

4. Study of counting statistics using background radiation using GM counter.

5. Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage.

6. Study of absorption of beta particles in Aluminum using GM counter.

7. Detection of α particles using reference source & determining its half-life using spark counter

8. Gamma spectrum of Gas Light mantle (Source of Thorium)

Reference Books

► W.E. Burcham and M. Jobes – Nuclear and Particle Physics – Longman (1995)

► G.F.Knoll, Radiation detection and measurements

► ThermoluninescenseDosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)

► W.J. Meredith and J.B. Massey, "Fundamental Physics of Radiology". John Wright and Sons, UK, 1989.

► J.R. Greening, "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book

Series, No.6, Adam Hilger Ltd., Bristol 1981.

► Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey, Cambridge University Press, U.K., 2001

► A. Martin and S.A. Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.

► NCRP, ICRP, ICRU, IAEA, AERB Publications.

► W.R. Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc. London, 1981

Course Outcomes:

From this course the students will learn about some basic ideas of atomic and nuclear physics. They will develop some ideas about the interaction of radiation with matter and types of radiation. They will get familiar with some radiation detection and monitoring devices and also gather knowledge regarding radiation quantities and units. Students will come to know about the biological effects of ionizing radiation. Students will be introduced to the field of radiation safety management. They will be familiar with the applications of different nuclear techniques.

5.4 SEC T4 – Weather Forecasting (2 Credits)

1. Introduction to atmosphere

Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics.

2. Measuring the weather

Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws

3. Weather systems

Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.

4. Climate and Climate Change

Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate

5. Basics of weather forecasting

Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.

Demonstrations and Experiments

1. Study of synoptic charts & weather reports, working principle of weather station.

2. Processing and analysis of weather data

a. To calculate the sunniest time of the year.

b. To study the variation of rainfall amount and intensity by wind direction.

c. To observe the sunniest/driest day of the week.

d. To examine the maximum and minimum temperature throughout the year.

e. To evaluate the relative humidity of the day.

f. To examine the rainfall amount month wise.

3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.

4. Formats and elements in different types of weather forecasts/ warning (both aviation and non-aviation)

Reference Books

► Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books

► The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.

► Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.

► Text Book of Agrometeorology, S.R. Ghadekar, 2005, Agromet Publishers, Nagpur.

► Why the weather, Charls Franklin Brooks, 1924, Chpraman& Hall, London.

► Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.

Course Outcomes:

From this course the students will get acquainted with various aspects of atmosphere. They will come to know about the weather systems, climate and climate change. Students will gather knowledge about the basics of weather forecasting when going through this course.

Generic Elective

SEMESTER-I

GE T1 – Mechanics, Electrostatics and Sound. (4 Credits)
1. Vector Analysis

Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter.

Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

2. Laws of Motion

Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of

Mass.

3. Momentum and Energy

Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

4. Rotational Motion

Angular velocity and angular momentum. Torque. Conservation of angular momentum.

5. Gravitation

Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications.

6. Elasticity

Hooke's law –stress-strain diagram, Elastic moduli- relation between elastic constants, poisson's ratio expression for Poisson's ratio in terms of elastic constants- work done in stretching and work done in twisting a wire – twisting couple on a cylinder –Determination of Rigidity modulus by static torsion- Torsional pendulum- Determination of Rigidity modulus and moment of inertia by Searles method.

7. Special Theory of Relativity

Postulate of special theory of relativity. Lorentz transformations. Simultaneity and order of events. lorentz contraction. Time dilation, relativistic transformation of velocity, relativistic addition of velocities.

8. Sound

Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential

Energy, Total Energy and their time averages. Linearity & Superposition Principle.

(1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. Damped oscillations. Forced vibrations and resonance.

Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria.

9. Electrostatics

Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarization, Displacement vector. Parallel plate capacitor completely filled with dielectric.

Reference Books

► University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley

► Mechanics Berkeley Physics, v.1: Charles Kittel, et.al. 2007, Tata McGraw-Hill.

► Physics – Resnick, Halliday& Walker 9/e, 2010, Wiley

► Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press

► University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Course Outcomes:

1. Students will learn and develop the concepts of vector and basic knowledge of the vector differential operator Del and understand the operation on the scalar and vector field.

2. Students will Learn and realize about vector theorems like Divergence and Green theorem etc.

3. Students will develop the concepts on classical mechanics and enhance the basic knowledge of the non-inertial and inertial frame of reference, variable mass, rocket motion, special theory of relativity.

4. They will acquire knowledge about the elasticity of the material and the streamline and turbulent motion.

5. Enhance the capability to prepare and organize a presentation on the application of fundamental dynamics.

6. They can understand the relation between electrical charge, electrical field, electrical potential

7. They can understand and realize the superposition of SHM collinearly and perpendicularly and can study the Beat ant Lissajous figures.

GE P1 – Mechanics, Electrostatics and sound
Lab (2 Credits) List of Practical

1. Measurements of length (or diameter) using verniercaliper, screw gauge and travelling microscope.

2. To determine the Moment of Inertia of a Flywheel.

3. To determine the Young's Modulus of a Wire by Optical Lever Method.

4. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.

5. To determine the Elastic Constants of a Wire by Searle's method.

6. To determine g by Kater's Pendulum.

7. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.

8. To investigate the motion of coupled oscillators

9. To study Lissajous Figures

10. To determine the Moment of Inertia of cylindrical body about an axis passing through its centre of gravity.

11. Frequency f vs 1/l curve for a sonometer- wire and hence unknown frequency of a tuning fork.

12. To determine the Modulus of Rigidity of a Wire by dynamical method.

Reference Books

► Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

► Engineering Practical Physics, S.Panigrahi&B.Mallick, 2015, Cengage Learning India Pvt.

Ltd.

► A Text Book of Practical Physics, InduPrakash and Ramakrishna, 11th Edition, 2011, KitabMahal, New Delhi.

Course Outcomes:

1. Student will learn how can use the screw gauge, slide callipers, microscope, telescope.
2. They are able know how experimentally measure the Young's modulus, coefficient of viscosity of liquid, acceleration due to gravity, spring constant.
3. They will acquire knowledge about Lissajous figures, coupled oscillations.
4. They can realize about the moment of inertia of body about the axis of rotation.

SEMESTER-II

GE T2 –Electromagnetism and Thermal Physics (4 Credits)
1. Magnetism

Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law.

Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro- magnetic materials.

Electromagnetic Induction

Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.

2. Maxwell`s equations and Electromagnetic wave propagation

Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves.

3. Kinetic Theory of Gases

Mean free path (zeroth order), Law of equipartition of energy (no derivation) and its applications to specific heat of gases, mono-atomic and diatomic gases.

4. Theory of Radiation

Blackbody radiation, Plank's distribution law (statement only), Stefan Boltzmann Law and

Wien's displacement law (statement only and graphical explanation)

5. Laws of Thermodynamics

Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

6. Statistical Mechanics

Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose- Einstein distribution law (Only distribution formula with explanation) comparison of three statistics.

Reference Books

► Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education

► Electricity & Magnetism, J.H. Fewkes&J.Yarwood. Vol. I, 1991, Oxford Univ. Press

► Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.

► University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

► D.J.Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.

► Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.

► A Treatise on Heat, MeghnadSaha, and B.N. Srivastava, 1969, Indian Press.

► Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.

► Heat and Thermodynamics, M.W.Zemansky and R. Dittman, 1981, McGraw Hill

► Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and

► G.L. Salinger. 1988, Narosa

► University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

► Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. chand Publications

Course Outcomes:

After completion of the course the students should understand the basic concepts about magnetic effect of current, basic concepts about different types of magnetic materials and electromagnetic induction. This course will help the students to understand Maxwell's equations and electromagnetic wave propagation through vacuum and isotropic dielectric medium. This course further enables the students to acquire knowledge about basic concepts of kinetic theory of gases and theory of radiation. They will also gain knowledge about laws of thermodynamics and their application to different thermodynamic processes. Students will also understand the fundamental concepts of statistical mechanics including some related distribution laws.

GE P2 – Electromagnetism and Thermal Physics Lab (2 Credits)
List of Practical

1. Measurement of Planck's constant using black body radiation.

2. To determine Stefan's Constant.

3. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.

4. To use a Multimeter for measuring

- Resistances
- AC and DC Voltages
- DC Current
- Checking electrical fuses.

5. Ballistic Galvanometer:

- Measurement of charge and current sensitivity
- Measurement of CDR
- Determine a high resistance by Leakage Method

6. To study the Characteristics of a Series RC Circuit.

7. To study a series LCR circuit LCR circuit and determine its

- Resonant frequency
- Quality factor

8. To determine a Low Resistance by Carey Foster's Bridge.

9. To verify the Thevenin and Norton theorems

10. To verify the Maximum Power Transfer Theorems

. 11. Resistance of suspended coil galvanometer by half deflection method and hence the current sensitivity of the galvanometer.

12. Potential difference across a low resistance and hence the current through it with the help of a meter bridge (without end correction)

13. To determine the coefficient of linear expansion of the material of a rod using Optical Lever Method

Reference Books

► Advanced Practical Physics for students, B.L.Flint&H.T.Worsnop, 1971, Asia Publishing House.

► Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

► A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed.2011, KitabMahal

Course Outcomes:

On performing the laboratory experiments they should have a preliminary overview and hands-on experiences on how some common experimental equipment related to electricity, magnetism and thermal physics can be used.

SEMESTER-III

GE T3 – Physical Optics and Modern Physics(4Credits)

1. Wave Optics

Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.

2. Interference

Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes);

Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength

and refractive index.
Diffraction

Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate.

3. Polarization

Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.

4. Crystal Structure

Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Unit Cell. Miller

Indices. Reciprocal Lattice. Types of Lattices. Diffraction of X-rays by Crystals. Bragg's Law.

5. Quantum Mechanics

Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle**.**

Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum & Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle

6. Nuclear Physics

General properties of atomic nucleus. Packing fraction, mass defect, binding energy, systematics of stable nuclei.

Radioactivity. Law of radioactive decay; Mean life and half-life. Transient and secular equilibrium.

Fission and fusion. Mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with U^{235}; Fusion and thermonuclear reactions.

Reference Books

► A Text book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, 2nd Ed., 2010, McGraw Hill

► Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.

► Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.

► Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.

► Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

► Quantum Mechanics for Scientists and Engineers, D.A.B. Miller, 2008, Cambridge University Press

► Quantum Mechanics, EugenMerzbacher, 2004, John Wiley and Sons, Inc

► Introduction to Quantum Mechanics, David J. Griffith, 2nd Ed. 2005, Pearson Education

► Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

► Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).

► Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).

► Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004)

► Introduction to Elementary Particles, D. Griffith, John Wiley & Sons

► Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi

► Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP-Institute of Physics Publishing, 2004).

► Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).

► Theoretical Nuclear Physics, J.M. Blatt &V.F.Weisskopf (Dover Pub.Inc., 1991)

► Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill

► Principles of Optics, B.K. Mathur, 1995, Gopal Printing

► Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications

► University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley

Course Outcomes:

1. Students will develop an understanding of the principles of optics.
2. To build connections between mathematical development and conceptual understanding.
3. Develop explicit problem-solving strategies that emphasize qualitative analysis steps to describe and clarify the problem.
4. They will understand the relationship between observation and theory and their use in building the basic concepts of modern physics.
5. They will understand how major concepts developed and changed over time.
6. They will Capable of analyzing and solving problems using oral and written reasoning skills based on the concepts of modern physics.

GEP3 - Physical Optics and Modern Physics Lab
(2 Credits)

List of Practical

1. Familiarization with Schuster`s focusing; determination of angle of prism.
2. To determine the Refractive Index of the Material of a Prism using Sodium Light.
3. To determine Dispersive Power of the Material of a Prism using Mercury Light

4. To determine the Resolving Power of a Prism.

5. To determine wavelength of sodium light using Newton's Rings

6. To determine the Resolving Power of a Plane Diffraction Grating.

7. To determine value of Boltzmann constant using V-I characteristic of PN diode.

8. To determine work function of material of filament of directly heated vacuum diode.

9. To determine value of Planck's constant using LEDs of at least 4 different colors.

10. Refractive index of water by traveling microscope.

11. Refractive index of the material of a lens by lens mirror method.

12. Refractive index of the liquid by lens- mirror method.

13. Focal length of a convex lens by combination method and calculation of its power.

Course Outcomes:

1. There is scope to learn how to use a spectrometer to study the spectrum of helium, sodium vapour.
2. They will acquire clear knowledge about prism, grating , single slit
3. They will learn experimentally about Newton's ring.
4. Students will also realize the resolving power of lens.
5. They can learn to handle the traveling microscope and using this they will be able to measure the refractive index of liquid.
6. They will understand about the power of the lens.

SEMESTER-IV

GE T4 - Electronics and instrumentation (4 credits)

1. Elementary band theory

Band Gaps. Conductors, Semiconductors and insulators. P and N type Semiconductors. Conductivity of Semiconductors, mobility, Hall Effect (only statement), Hall coefficient.

2. Semiconductor Devices and Amplifiers

Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structure of

(1) LEDs, (2) Photodiode, (3) Solar Cell

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cutoff& Saturation regions Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line & Q- point. Voltage Divider Bias Circuit for CE Amplifier. H-parameter, Equivalent Circuit. Analysis of single-stage CE amplifier using hybrid Model. Input & output Impedance. Current, Voltage and Power gains. Class A, B & C Amplifiers.

3. Operational Amplifiers (Black Box approach)

Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed- loop Gain. CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non- inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator.

4. Digital Electronics

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map

Binary Addition. Binary Subtraction using 2's Complement Method). Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor.

5. Instrumentations

Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation.

Reference Books

► Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.

► Electronic devices & circuits, S. Salivahanan& N.S. Kumar, 2012, Tata Mc-Graw Hill

► Microelectronic Circuits, M.H. Rashid, 2nd Edn., 2011, Cengage Learning.

► Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990, PHI Learning.

► Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill

► Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.

► Fundamentals of Digital Circuits, A. Anand Kumar, 2nd Edition, 2009, PHI Learning Pvt. Ltd.

► OP-AMP & Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.

GE P4 – electronics and Instrumentation Lab. (2 Credits)

List of Practical

1. To verify and design AND, OR, NOT and XOR gates using NAND gates.
2. To minimize a given logic circuit.
3. Adder-Subtractor using Full Adder I.C.
4. Study of zener diode characteristics and its application as voltage regulator.
5. To study the characteristics of a Transistor in CE configuration.
6. To design a CE amplifier of given gain (mid-gain) using voltage divider bias.
7. To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response.
8. To design a non-inverting amplifier of given gain using Op-amp 741 and study its Frequency Response.
9. Band gap measurement of for thermistor.
10. To draw the I-V characteristics of a suitable resistance and that of a junction diode within specified limit on a graph, and hence to find d.c. and a.c. resistance of both the elements at the point of intersection.